

## PSYCHE.

### MOSQUITOES CONSIDERED AS TRANSMITTERS OF YELLOW FEVER AND MALARIA.

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THE despised mosquito, denounced by me since 1881 as the agent of transmission of yellow fever, is now attracting considerable attention among distinguished and sagacious observers who attribute to that insect an important rôle in the etiology and propagation of the malaria infection. To those who are familiar with the biological conditions and the habits of the mosquito, this will not be a matter for surprise; rather should we wonder how, considering the special aptitudes of the insect, other inoculable diseases are not equally transmitted by it, especially such as are due to germs in the blood or in the tissues that lie within reach of its sting. Much light, however, has been thrown upon this singular eclecticism by modern ideas concerning the process by which some blood-sucking insects convey certain diseases to warm-blooded animals. We are induced by them to regard as one of the essential conditions that the transmitting insect should itself experience a true infection, which may not endanger its life nor greatly disturb its physiological functions, but must always

require, on the part of the insect, pathogenous susceptibility for the specific germs which it is called upon to transmit. It will thus be readily understood why the same insect may transmit only certain germs and not others, as also that, among insects of the same kind, some species may possess that faculty while others do not.

Among the publications that have appeared concerning the transmission of malaria by mosquitoes, the most important one, and that which has caused most sensation, has been the lecture delivered, a few months ago, by Robert Koch, in which he declares himself decidedly in favor of the mosquito theory as the one which most plausibly accounts for the propagation of the said disease. In support of his idea he cites a very appropriate precedent, the Texas fever, a cattle disease, the etiology and propagation of which were so ably cleared up in 1892 by Dr. Theobald Smith, chief of the division of animal pathology in the Bureau of Animal Industry, United States of America. Dr. Smith proved that the germ of the

disease is a blood-parasite, and that it is propagated by the cattle tick. The germs sucked in with the blood of diseased cattle reach the eggs of the tick, and the new generation of ticks, developed from the infected eggs, convey the Texas fever to the sound cattle upon which they are applied. His experiments were repeated and confirmed in Eastern Africa by Koch, who in view of the relations which seem to connect the presence of mosquitoes with the transmissibility of malaria, does not hesitate to make those insects responsible for the propagation of the malaria infection. He does not think, however, that the latter can be communicated by so simple a process as that of a mosquito first stinging a malaria patient and afterward a sound person, such as I have, in my theory, considered capable of causing the transmission of yellow fever. The grounds for this distinction, however, are not very apparent. In the case of the tick, which is supposed not to attack a second animal after parting from its first host, the exclusive transmission by the second generation, infected through the eggs, may be considered a necessity; but it is otherwise with mosquitoes, at any rate with those which I have observed in Havana. After an interval of two or more days, which they require to digest the blood and empty themselves, they are ready to sting the next victim that offers, and may do so as many as ten or twelve times, during the thirty or more days that I have been able to keep them alive. It is, therefore, quite

admissible that, when the mosquito becomes contaminated, not only its eggs but also its salivary and venom glands may be invaded by the pathogenous germs, so that the latter may be discharged with the secretion of those glands along the track of the wound and into the capillary vessel entered by the sting when the insect attacks its next victim. Indeed, on some rare occasions I have seen mosquitoes die within twenty-four hours after they had stung a patient with severe yellow fever, without assignable cause, for they still retained some of the blood which they had sucked; whence it might be surmised that the yellow-fever germ is pathogenic for the Havana mosquitoes, though the infection seldom proves fatal for those insects.

In August last, during my stay in the field hospitals on the hills near Santiago, I witnessed a fact which, as far as it went, agreed with my theory about yellow fever, inasmuch as there were neither mosquitoes, mosquito eggs, nor larvae to be found in my encampments, and not a single case of yellow fever occurred among the one hundred and fifty men who came under my observation, notwithstanding the daily communications with the city. It was otherwise, however in regard to malaria, for this constituted the prevalent cause of sickness in all those camps. It assumed various types: the quotidian or tertian intermittent, the remittent, irregular, or subcontinuous; but in most of the cases it was accompanied by diarrhoea (sometimes mixed with

blood). This instance, at any rate, shows that Koch's assertion, that "where there are no mosquitoes there is no malaria," is altogether too absolute. In those camps, I believe the propagation must have been effected through the flies (of which there was a great abundance). These insects, in spite of all precautions, had ample opportunities of picking up, from the discharges of the malaria patients, not only the malaria parasites contained in the extravasated blood, but also some infectious intestinal germ, with both of which organisms they may have contaminated the food and beverages used by the men who subsequently showed signs of the double infection. A yellow-fever epidemic occurring under similar circumstances, in the absence of yellow-fever mosquitoes, might not be so readily reconciled with my theory about that disease, which is founded upon more definite and more exclusive arguments than those recorded in connection with the malaria infection. The following instance may serve to illustrate my meaning. In the capital of Mexico, and in other districts of similar altitude above the sea level, Mexicans who never have visited the lowlands have no immunity whatsoever against yellow fever, a sure proof that no epidemics of that disease ever occur in that part of the country. It sometimes happen, however, that a resident of the capital takes the infection by going to Vera Cruz, though the disease may not declare itself until his return to the capital. In such cases,

the yellow fever will run its usual course, with the same symptoms and prognosis as if the patient had remained at Vera Cruz; with this difference only: that in Vera Cruz other susceptible persons might readily have caught the infection from him, whereas in Mexico the disease is never propagated. If the infection could be transmitted through contact with the patient or his secretions, by inhaling his emanations in the sick room, or by the use of contaminated food or beverages, there would be no imaginable reason why the disease should not be transmitted at Mexico as well as at Vera Cruz. Such not being the case, we must infer: first, that a factor which is necessary for the transmission is present at Vera Cruz, but is absent from Mexico; and second, from the circumstance of the disease not being transmissible through the forms of exposure enumerated above, that the yellow-fever germ is pathogenic only when introduced in a less trivial manner, probably by inoculation under the epidermis or even directly into a blood-vessel. Hence my theory of the mosquito.

*New Mosquito Theory.*—My original mosquito theory, however, in view of the facts brought to light by Dr. T. H. Smith, in his admirable demonstration of the transmission of the Texas fever through the agency of the cattle tick, requires now to be somewhat modified, so as to include the important circumstance that the faculty of transmitting the yellow-fevergerm need not be limited to the parent insect, directly

contaminated by stinging a yellow-fever patient (or perhaps by contact with or feeding from his discharges), but may be likewise inherited by the next generation of mosquitoes issued from the contaminated parent. With this new development, indeed, the theory seems to cover the whole ground of conditions which are known to govern the transmission or non-transmission of the disease, and to account for every well authenticated fact on record.

There are different species of mosquitoes which are peculiar to certain localities, even within the yellow-fever zone, though we are not able to account for their preferences in this respect, nor for the circumstances which determine their permanency in such limited areas. It is a fact, however, that the "domestic mosquito" (by which term I mean such species as constitute a parasite and commensal of man) shows no inclination whatever for extensive excursion so long as the female insects find at hand convenient subjects from whom they can draw the warm life-blood which they apparently require, not so much for their own nourishment as for the purposes of ovulation and for the reproduction of their species. That the tropical species cannot well establish themselves in temperate or cold climates, will be readily understood by repeating the following experiments: Let a mosquito of the small diurnal species found in Havana be introduced into a test tube provided with a thermometer; if the temperature be lowered, it will be seen that, when it falls

to between  $15^{\circ}$  and  $19^{\circ}$  C. ( $59^{\circ}$  and  $66.2^{\circ}$  F.), the insect becomes benumbed, and unless it finds some object upon which it can fasten its claws it will drop to the bottom of the tube, in a condition of apparent death, in which it will remain so long as the temperature is kept between  $15^{\circ}$  and  $0^{\circ}$  C. ( $59^{\circ}$  and  $32^{\circ}$  F.). On allowing the temperature to rise again, when it reaches above  $15^{\circ}$  to  $19^{\circ}$  C. the mosquito will gradually revive and soon recovers its normal agility and the power of stinging. On the other hand, if the mosquito is confined in a closed tube and the air gradually rarefied, the insect appears to lose the power of supporting itself on its wings, and also that of stiffening its proboscis for the purpose of stinging. With temperatures below  $25^{\circ}$  C. ( $77^{\circ}$  F.), the time required by the culex mosquito to digest the blood and get ready for another bite is prolonged to several days; and, according to my observations, the pupae of that species, if kept at temperatures below  $23^{\circ}$  C. give five males to one female, whereas at  $25^{\circ}$ - $30^{\circ}$  C. the proportions are reversed. Hence it follows that during the cold season in Havana there are comparatively few mosquitoes of that kind in a condition to propagate the yellow fever. At sea mosquitoes will save themselves from being blown into the water only by avoiding the deck and other exposed parts of a vessel, and in travelling toward cooler regions they will have an additional motive for seeking refuge in the warmer and more sheltered parts of the ship. Hence the likelihood of

their gathering in the holds of vessels, in which the source of yellow-fever infections has been, many a time, distinctly located. Once boxed up inside the hold of a vessel, the contaminated mosquito may be reduced to the necessity of drawing its blood supply (*faute de mieux*) from lower animals, such as rats, etc., and to lay its eggs in any collection of fresh water that may have found its way through the chinks or otherwise. On land, mosquitoes will instinctively frequent the basement or ground floor of houses in preference to the upper ones, and they seldom seek the open air of their own accord, while their usual functions can be fulfilled under shelter, except when they are ready to lay their eggs. This is in accordance with the maternal instinct which teaches them to procure undisturbed possession of some stagnant waters for their larvae during the two or more weeks required for the complete development of the winged insect; a condition seldom satisfied within inhabited dwellings. On the approach of its natural death, the parent insect returns to the same waters where its eggs have been laid, and its cadaver remains floating on the water, to be devoured by its own larvae. Entrapped during the unconscious act of a person putting on his hat in a contaminated locality, mosquitoes may be conveyed to distant houses; and inside of boxes, trunks, parcels, etc., provided that a sufficient degree of moisture and particles of available food exist in their place of confinement, they can be

conveyed to any distance that may be reached within the natural term of the insect's life (which sometimes lasts as many as thirty or thirty-five days).

My experiments upon yellow-fever mosquitoes have already been published; their results may be thus briefly recorded: first, Reproduction of the disease, in a mild form, within five to twenty-five days after having applied contaminated mosquitoes to susceptible subjects; second, partial or complete immunity against yellow fever, obtained even when no pathogenous manifestation had followed those inoculations; third, finally, the coincidence of cultures made with the heads and proboscides of contaminated mosquitoes giving the identical micrococcus in tetrads (*M. tetragenus febris flavae*; *M. tetragenus versatilis*, Sternberg; *tetracoccus versatilis*) previously discovered by me, in collaboration with Dr. C. Delgado, in the blood and secretions of yellow-fever patients.

With such an array of evidence (presumptive or otherwise) as to the rôle of the mosquito in the propagation of yellow fever, and the concurrence of Koch, Manson, and other experts of the highest order in their advocacy of a similar doctrine for the transmission of malaria, the time seems at last come when decided measures of protection against mosquitoes should be seriously considered; the more so as the energetic spirit of the Anglo-Saxon race is about to replace the fatalistic apathy of former rulers in Cuba and Porto Rico. The suggestion of Koch, calling for

dwelling from which mosquitoes could be barred out, in order that the German colonies of Eastern Africa might be freed from malaria, ought surely to be acted upon in countries where it is not only malaria that has to be contended with, but also the dreadful yellow fever, aptly called the "plague" in the early Spanish chronicles of America, from its analogies with the Oriental disease of that name. Why should not the houses, in yellow-fever countries, be provided with mosquito blinds, such as are used in the United States as a mere matter of comfort, whereas here it might be a question of life or death? The mosquito larvae might be destroyed in swamps, pools, privies, sinks, street-sewers, and other stagnant waters, where they are bred, by a methodical use of permanganate of potassium or other such substances, in order to lessen the abundance of mosquitoes; but the most essential point must be to prevent those insects from reaching yellow-fever patients, and to secure a proper disinfection of all suspicious discharges, in order to forestall the contamination of those insects. Well ventilated hospitals should be built on high grounds, with

no stagnant waters or marshes in their vicinity, the doors and windows protected by mosquito blinds, a good system of drainage and sewerage, with facilities for disinfecting all suspicious discharges, and for destroying such mosquitoes and larvae as might be found within the building. Only the upper stories should be occupied by the sick, and none but yellow-fever patients, and such malaria patients as are immune against yellow-fever, should be admitted. The examination for admission might be carried out in a separate building, and a separate department devoted to suspicious cases under observation.

With such hospitals at hand, and an efficient board of health that would see to the proper arrangements for patients who could be left in their homes, and general sanitary improvements in and around the principal cities, there can be little doubt that yellow fever might be stamped out of Cuba and Porto Rico, and malaria reduced to a minimum. It would then be the business of the port and quarantine officers to prevent the introduction of fresh germs.

## THE COMMOTION IN KANSAS AND MISSOURI UPON THE APPEARANCE OF DISSOSTEIRA IN COLORADO.

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In looking over the literature upon *Dissosteira longipennis* Thos., I was surprised to find that no detailed record

had been made, in literature readily accessible to entomologists, of the grave fears in Kansas and Missouri caused by